Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number	Candidate Number

Physics

International Advanced Level
Unit 4: Further Mechanics, Fields and Particles

Sample Assessment Materials for first teaching September 2018

Time: 1 hour 45 minutes

Paper Reference
WPH14/01

You must have:
Scientific calculator, Ruler

Total Marks

Instructions

- Use **black** ink or **black** ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Show all your working out** in calculations and include units where appropriate.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

SECTION A

Answer ALL questions.

For questions 1–10 select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A current-carrying conductor of length 15 cm is placed in, and perpendicular to, a magnetic field of magnetic flux density 0.065 T. The current through the conductor is 250 mA.

Which of the following is the force on the conductor, in newton, due to the magnetic field?

☒ **A** $0.065 \times 250 \times 15$

☒ **B** $0.065 \times 0.25 \times 15$

☒ **C** $0.065 \times 250 \times 0.15$

☒ **D** $0.065 \times 0.25 \times 0.15$

(Total for Question 1 = 1 mark)

2 $^{18}_{8}O$ is a stable isotope of oxygen.

Which row of the table correctly shows the number of neutrons and the number of protons in a nucleus of $^{18}_{8}O$?

	Number of neutrons	Number of protons
☒ **A**	8	10
☒ **B**	9	9
☒ **C**	10	8
☒ **D**	18	8

(Total for Question 2 = 1 mark)

3 Which of the following is **not** a vector quantity?

☒ **A** angular velocity

☒ **B** electric field strength

☒ **C** impulse

☒ **D** magnetic flux density

(Total for Question 3 = 1 mark)

4 Which of the following correctly expresses the unit of magnetic flux density in SI base units?

☒ **A** $A\ s^2\ kg^{-1}$

☒ **B** $kg\ A^{-1}\ s^{-2}$

☒ **C** $kg\ s^{-3}\ C^{-1}$

☒ **D** $N\ A^{-1}\ m^{-1}$

(Total for Question 4 = 1 mark)

Questions 5 and 6 refer to the following situation.

A toy bird is moving around in a horizontal circle on the end of a piece of string.

5 Which of the following changes would cause a decrease in the tension in the string?

☒ **A** increasing the angular velocity of the toy bird

☒ **B** increasing the mass of the toy bird

☒ **C** increasing the period of rotation of the toy bird

☒ **D** increasing the speed of the toy bird

(Total for Question 5 = 1 mark)

6 The toy bird makes 15 full revolutions in 7 s.

Which of the following gives the angular velocity of the toy bird in $rad\,s^{-1}$?

☒ **A** $\frac{15 \times \pi}{7}$

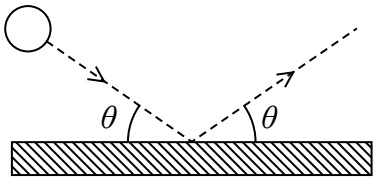
☒ **B** $\frac{15 \times 2\pi}{7}$

☒ **C** $\frac{7 \times \pi}{15}$

☒ **D** $\frac{7 \times 2\pi}{15}$

(Total for Question 6 = 1 mark)

7 A ball with momentum p collides with a wall at an angle θ and bounces off with the same speed at the same angle. The collision takes time t.



View from above

Which of the following equations gives the mean force F acting on the ball during the collision?

☒ **A** $F = \dfrac{p\sin\theta}{t}$

☒ **B** $F = \dfrac{2p\sin\theta}{t}$

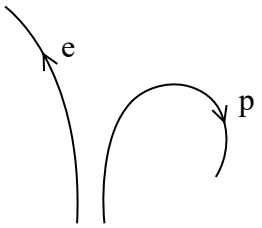
☒ **C** $F = -\dfrac{p\sin\theta}{t}$

☒ **D** $F = -\dfrac{2p\sin\theta}{t}$

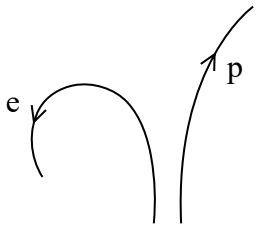
(Total for Question 7 = 1 mark)

8 A proton p and an electron e, with the same velocity, enter a magnetic field that is perpendicular to the direction of their motion. The field acts out of the page.

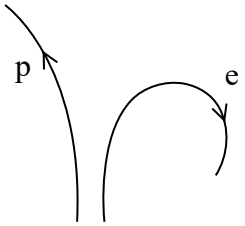
Which of the following diagrams best represents the motion of the particles?



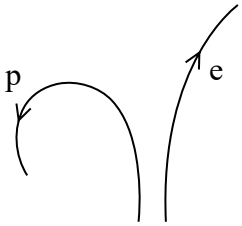
☒ **A**



☒ **B**



☒ **C**



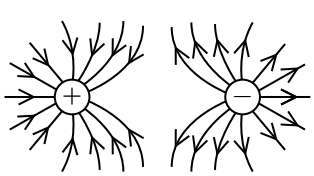
☒ **D**

(Total for Question 8 = 1 mark)

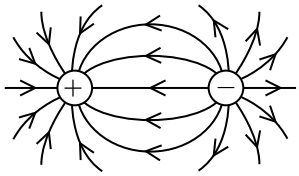
Questions 9 and 10 refer to the following situation.

A point positive charge $+Q$ and a point negative charge $-Q$ are separated by a distance r.
The magnitude of the force between the charges is F.

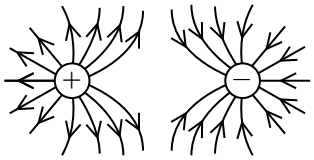
9 Which of the following diagrams shows the electric field pattern?



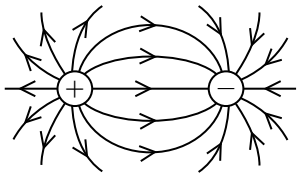
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for Question 9 = 1 mark)

10 The size of each charge is decreased to $\frac{Q}{2}$ and the separation is decreased to $\frac{r}{4}$.

What is the magnitude of the force between these charges?

☒ **A** $\frac{F}{4}$

☒ **B** $\frac{F}{2}$

☒ **C** $2F$

☒ **D** $4F$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions.

11 Determine the electric field strength due to a point charge of −37 nC, at a distance of 5.5 cm from the point charge.

Magnitude of electric field strength = ...

Direction of electric field .....

(Total for Question 11 = 3 marks)

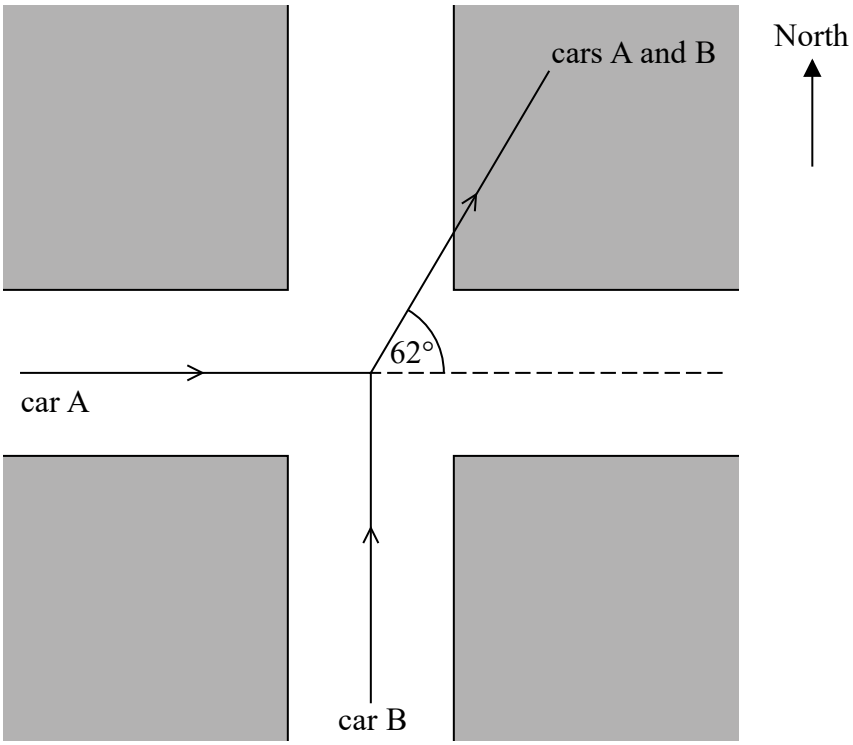
12 The table shows the six flavours of quarks and their charges.

Quark			Charge/*e*
u	c	t	$\frac{2}{3}$
d	s	b	$-\frac{1}{3}$

Explain why all mesons have charge +*e*, 0 or −*e*.

(Total for Question 12 = 4 marks)

13 Car A was travelling eastwards and car B was travelling northwards. The two cars collided and moved off together in the direction shown. The diagram is not to scale.



(a) After the collision the cars travelled a distance of 11 m together. The constant deceleration for the cars was 2.4 m s^{-2}.

Show that the initial speed of the cars together after the collision was about 7 m s^{-1}.

(2)

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(b) Each driver claimed that the other driver was speeding. The speed limit for car A was 30 km/h (8.3 m s^{-1}) and the speed limit for car B was 50 km/h (13.9 m s^{-1}).

Calculate the speed of each car before the collision to determine whether either car was speeding before the collision.

mass of car A = 1100 kg
mass of car B = 1400 kg

(6)

Speed of car A = ...

Speed of car B = ...

Conclusion

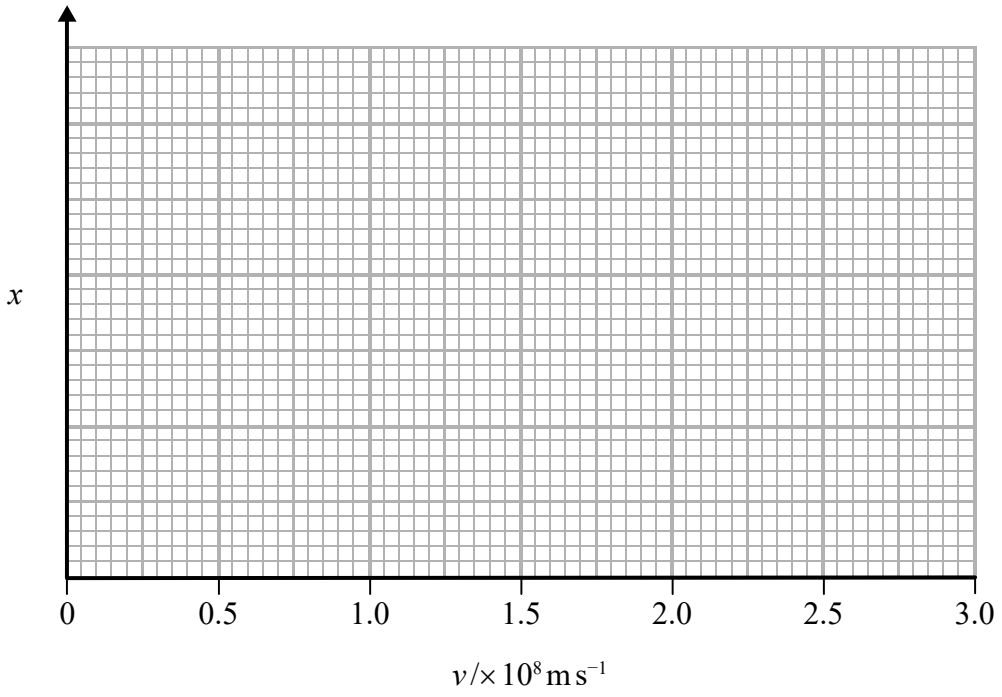
(Total for Question 13 = 8 marks)

14 Particle tracks in detectors can be used to determine the distance travelled by particles between creation and decay.

One type of particle, with a known average lifetime, travels an average distance x between creation and decay when its speed is v.

(a) Sketch a graph on the axes below to show how x varies with v, until v approaches the speed of light.

(2)



(b) Explain the shape of the graph.

(3)

(Total for Question 14 = 5 marks)

15 Black holes have such high gravitational field strength that nothing, including light, can escape from within them.

It has been suggested that black holes can lose mass over time.

Energy from a black hole allows the production of a particle-antiparticle pair outside the black hole. The two particles move off in opposite directions. One particle falls into the black hole and the other escapes. Therefore the energy of the escaping particle is lost by the black hole.

(a) The particles created are a muon and an anti-muon, each with mass 106 MeV/c^2.

Calculate the minimum mass, in kg, lost by the black hole.

(3)

Minimum mass = ... kg

(b) Explain why the mass calculated in (a) is a minimum value.

(2)

(Total for Question 15 = 5 marks)

16 Rutherford's alpha particle scattering experiments led to the conclusion that an atom is mostly empty space and contains a massive charged nucleus.

An alpha particle of energy 7.7 MeV is moving along a path directly towards a gold nucleus.

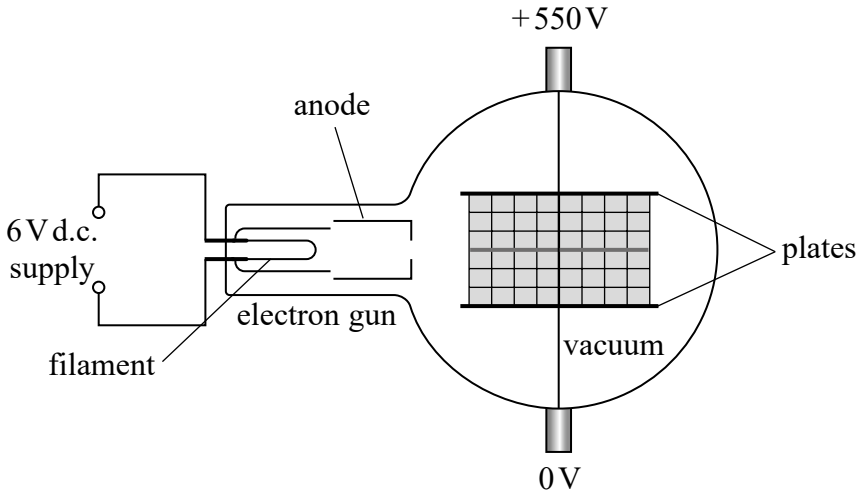
Determine whether the closest distance of the alpha particle to the centre of the nucleus is consistent with this conclusion.

diameter of gold atom = 2.6×10^{-10} m
charge on a gold nucleus = $+79e$

(5)

(Total for Question 16 = 5 marks)

17 The diagram shows an electron deflection tube that includes an electron gun and two parallel plates.



(a) The electron gun consists of a hot metal filament and a positively charged anode.

Describe how this produces a beam of electrons.

(2)

(b) A potential difference of 550 V is applied across the parallel plates to create a uniform electric field between them. The beam of electrons is deflected upwards by this electric field.

The vertical separation of the plates is 5.0 cm and the beam enters horizontally halfway between them. The initial speed of the electrons in the beam as they enter the space between the plates is $2.7 \times 10^7 \text{ m s}^{-1}$.

length of plate = 10 cm

(i) Determine whether the beam will hit the top plate.

(6)

(ii) Calculate the de Broglie wavelength of an electron moving at a speed of $2.7 \times 10^7 \text{ m s}^{-1}$.

(2)

Wavelength = ...

(Total for Question 17 = 10 marks)

18 Neutrons in a nucleus are stable. However, free neutrons decay with a mean lifetime of about 15 minutes.

The decay of a neutron is given by

$$n \rightarrow p + e^- + \bar{\nu}_e$$

(a) Describe how three conservation laws apply to this decay.

(6)

Law 1: .....

Law 2: .....

Law 3: .....

(b) A stationary free neutron decays. It may be assumed that only the electron has significant kinetic energy after the decay.

The table gives the mass of the particles involved in the decay. The mass of the neutrino may be considered to be negligible.

	Mass / MeV/c^2
Neutron	939.5656
Proton	938.2723
Electron	0.5110

Determine the momentum of the electron.

(4)

Momentum = ...

(Total for Question 18 = 10 marks)

19 The European Laboratory for Particle Physics is operated by CERN and contains the Large Hadron Collider (LHC).

Protons go through a number of stages in different accelerators before they enter the LHC.

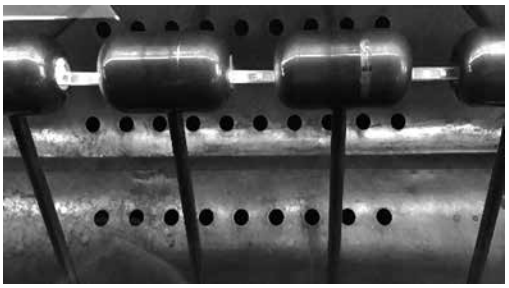
The first stage is a linear accelerator (linac).

*(a) The photographs show the drift tubes at the beginning and at the end of a linac.

The beam of protons travels from left to right.

drift tubes at the beginning of the linac

drift tubes at the end of the linac



direction of travel of proton beam

Explain why the drift tubes and the gaps between them increase in size along the length of the linac.

(6)

(b) The LHC has a number of straight sections with curved sections between them. The curved path of protons is maintained by a strong magnetic field. The radius of the curved path is given by $r = p/BQ$.

(i) Derive the equation $r = p/BQ$.

(3)

(ii) Protons of energy 6.5 TeV move along a curved path of radius 2800 m. At these energies, particle energy $E = pc$ where c is the speed of light.

Calculate the magnetic flux density required.

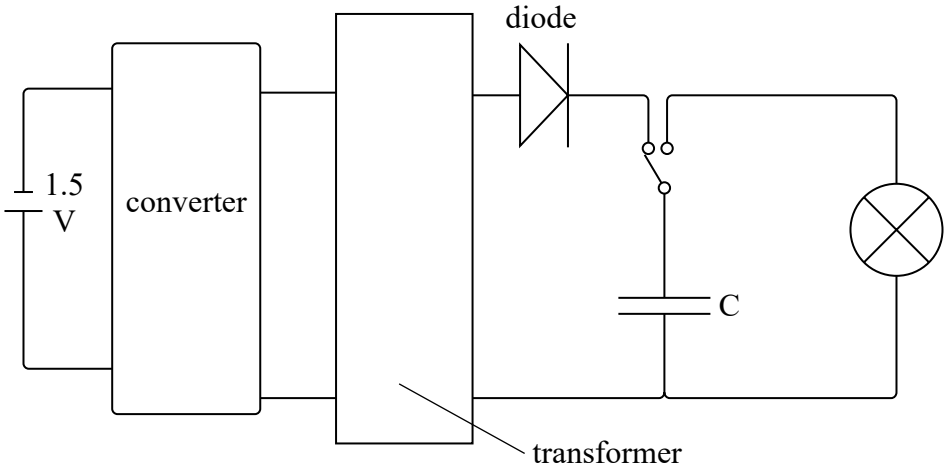
(3)

Magnetic flux density = ...

(Total for Question 19 = 12 marks)

20 A flash bulb for a camera must transfer a lot of energy in a very short time. This requires a higher potential difference (p.d.) than can be provided by a 1.5 V cell. A capacitor is used that can be charged to a p.d. over 300 V.

The diagram represents a simplified circuit for a camera flash unit.



Direct current from the cell is converted to alternating current by this converter.

The transformer increases the p.d. and the capacitor is charged. When the flash is required, the capacitor is connected in series with the bulb, which then flashes briefly.

(a) The transformer consists of two coils wound around a common iron core. One coil is connected in series with the converter. The second coil is connected to the capacitor circuit.

(i) Explain how this arrangement creates a current in the capacitor charging circuit.

(4)

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(ii) Explain why the diode must be included in this circuit.

(2)

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(b) The capacitor is charged until the p.d. across it reaches 330 V.

(i) Calculate the charge on the capacitor when the p.d. reaches 330 V.

capacitance of capacitor = 180 μF

(2)

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.....

.....

Charge = ...

(ii) Calculate the energy stored by the capacitor.

(2)

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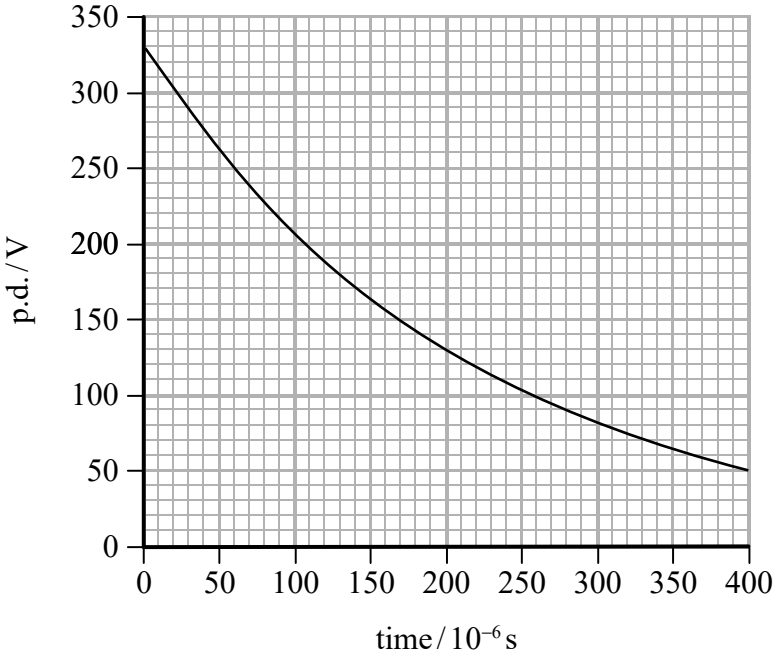
Energy = ...

(iii) The graph shows how the p.d. across the capacitor varies with time as the capacitor discharges.



1. Calculate the initial current in the capacitor circuit as the capacitor discharges.

(4)

Initial current = ...

2. Determine the time taken for the energy stored on the capacitor to reduce by 80%.

(4)

Time taken = ...

(Total for Question 20 = 18 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

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